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VOL. XV. 2. FEBRUARY, 1862.

THE

JOURNAL

OF

THE CHEMICAL SOCIETY.

Committee of Publication.

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N° LVIII.

LONDON:
HIPPOLYTE BAILLIERE, 219, REGENT STREET.
1862.

Price One Shilling.

LONDON: PRINTED BY HARRISON AND SONS, ST. MARTIN'S LANE, W. C.

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IX.—*Note on a Method of effecting the substitution of Chlorine for Hydrogen in Organic Compounds.*

By Hugo Müller.

In the investigation of Burmese naphtha, made a few years ago by Mr. Warren De La Rue and myself, we endeavoured to obtain some definite iodine-compounds of the hydrocarbons contained in it, by acting upon them with mono-and ter-chloride of iodine, hoping that this reagent would act in this case in a similar way to that observed a short time before by Brown, in the case of pyromeconic acid. These experiments did not however give the expected result, but merely the same chlorine-compounds that were already obtained by using chlorine only. The result was the same when iodine was dissolved in the hydro-carbon and chlorine passed into the deep violet-coloured solution. The only difference observable between the action of chlorine in presence of iodine and that of chlorine only, was that, in the former case, the action took place much more quickly than in the latter.

Having some time ago commenced a series of experiments with the view of obtaining from benzole the corresponding alcohol and acid, I had occasion to investigate the action of chlorine on this hydrocarbon.

Chlorine is absorbed to some extent by benzole, but if light be excluded, no perceptible action takes place until the benzole is heated to the boiling point; hydrochloric acid is then liberated and chlorine-derivatives are formed, but very slowly. In this reaction two series of compounds are formed, namely,

$C_6H_6Cl_2$,	$C_6H_6Cl_4$,	$C_6H_6Cl_6$, and
C_6H_5Cl,	$C_6H_4Cl_2$,	$C_6H_3Cl_3$

The experience gained in the above-mentioned experiments with Burmese naphtha, induced me to try upon a large scale the action of chlorine upon benzole in the presence of iodine.

When chlorine is passed into a saturated solution of iodine in benzole, it is completely absorbed, even when the current is moderately rapid, and after the violet solution has become brownish red, owing to the formation of monochloride of iodine, hydrochloric

acid is liberated and chlorine-derivatives are rapidly formed. In this way, I have obtained the compounds C_6H_5Cl, $C_6H_4Cl_2$, $C_6H_3Cl_3$, and when an excess of chlorine was used, a beautiful crystalline compound, which was previously obtained in small quantities on treating the hydrocarbons of Burmese naphtha in the same manner. It deserves to be noticed, that whereas when chlorine acts alone upon benzole, the chief products of the reaction are formed by its direct union with the hydrocarbon, the action of chlorine in presence of iodine gives rise to substitution-products and the evolution of hydrochloric acid.

I reserve the detailed description of the products of this reaction, and the method of obtaining them in a pure state for a future communication; what I wish especially to draw attention to upon this occasion is the remarkable effect of iodine in facilitating the action of chlorine upon organic compounds. I have already ascertained that many substances which are acted upon with great difficulty by chlorine alone, and some of them only with the aid of direct sunlight, yield chlorine-products with great ease when acted upon, in the manner described, by chlorine in the presence of iodine.

I have found for instance that benzoic acid dissolved, together with some iodine in chloroform, is acted upon by chlorine very readily, with evolution of hydrochloric acid.

Bisulphide of carbon in which iodine is dissolved is acted upon by chlorine very freely at its boiling point, giving chloride of carbon, chloride of sulphur, and a highly volatile substance having a very irritating and pungent odour, which is perhaps the chlorosulphide of carbon which Kolbe believed he had obtained by exposing sulphide of carbon to the action of chlorine in direct sunlight. The process I have described promises to give this substance in sufficient quantity to admit of ascertaining its true nature.

When chlorine is passed into a solution of iodine in glacial acetic acid in the cold, terchloride of iodine is formed, but the acid is not acted upon. If however the acid is kept boiling whilst the chlorine is being passed into it, hydrochloric acid is given off and chloracetic acid is formed, even in the dark. This affords a ready means of obtaining chloracetic acid, a substance whose preparation according to the usual method requires the aid of strong sunlight, and is commonly very tedious. If the action of chlorine be continued, a higher chlorinated acid is obtained, which

does not solidify even at 0° C., and which appears to be bi-chloracetic acid.*

It seems likely, that in this reaction, the iodine acts merely as a carrier and condenser of the chlorine; the effect is very similar to that of some perchlorides, like pentachloride of antimony, and in some cases pentachloride of phosphorus, which act upon many organic substances as if they were mixtures of terchlorides with free chlorine.

I may instance here the formation of Dutch liquid from olefiant gas and pentachloride of antimony, according to Wöhler, and the case of the transformation of bisulphide of carbon into chloride of carbon and chloride of sulphur by means of pentachloride of antimony mentioned by Hofmann.

On comparing the action of pentachloride of antimony with that of chlorine, in presence of iodine, upon the substances above mentioned, I find that the former agent is rather more energetic and possesses a tendency to produce the higher chlorinated derivatives.

Benzole added in small quantities to pentachloride of antimony, is acted upon with great violence, and there is at once formed a chlorinated derivative, which crystallises in beautiful white prisms nearly insoluble in alcohol, and not acted upon by alcoholic potash.

Succinic acid, when brought in contact with pentachloride of antimony, soon evolves hydrochloric acid, and if the reaction is supported by application of heat, chlorosuccinic acid is formed. If however the mixture of succinic acid with pentachloride of antimony be kept warm whilst a current of chlorine is passing into it, the succinic acid is gradually decomposed into volatile products.

I am still engaged with the examination of some new products of these reactions, a full account of which I hope shortly to lay before the Society.

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* Since the above was written I have found that, together with the chloracetic acid, there is invariably some iodacetic acid formed, and it appears that the formation of the latter is favoured by an excess of iodine used in the process. I have not ascertained whether the remarkable compounds lately obtained by Schützenberger by the action of chloride of iodine upon acetate and benzoate of sodium are formed when chlorine acts upon acetic and benzoic acid in the presence of iodine; but as these compounds are already decomposed at 100° C. their formation can hardly be expected under the circumstances.

X.—*On the Constitution of Anthracene or Paranaphthalin and some of its Products of Decomposition.*

By Thomas Anderson, M.D., F.R.S.E.,
Professor of Chemistry in the University of Glasgow.

[Abstracted from the Transactions of the Royal Society of Edinburgh, vol. xxii, part iii.]

The solid compounds of carbon and hydrogen form a class of substances to which chemists have scarcely, as yet, paid that attention which their importance and interest appear to merit. With the exception of naphthalin, very little is known regarding them, and it is remarkable that the numerous and varied products of decomposition obtained from that singular substance should not have induced a more minute examination of the kindred compounds, whose existence has been indicated by different chemists. The interest attaching to these compounds is all the greater, because, according to their discoverers, several of them are isomeric, or at least polymeric, with naphthalin; and a more careful examination of them might be expected to throw some light on their intimate constitution and their relations to that body.

No fewer than five substances said to be polymeric with naphthalin have been described. These are *paranaphthalin* or *anthracene*, *metanaphthalin* or *retisterene*, *pyrene*, and two substances not yet named, which occur, together with benzene and benzophenone, among the products of the destructive distillation of benzoate of lime, and are apparently quite distinct from one another and the other three. All of these substances, except naphthalin, have hitherto been obtained in small, and some of them in very minute quantity, so that their constitution has been in most instances fixed by analysis alone; and the difficulties attending the analysis of highly carbonaceous compounds at the time they were made, as well as the absence of any control derived from the examination of their products of decomposition, have naturally occasioned some doubts as to the accuracy of the formulæ assigned to them.

Paranaphthalin or anthracene, which was discovered by Dumas

and Laurent in the year 1832,* is the only one of these substances whose examination has extended beyond the mere analysis; and the determination of its vapour-density by the former chemist gave for it the formula $C_{30}H_{12}$, which the examination of some of its decomposition-products by the latter was supposed to confirm. A critical examination of Laurent's experiments by no means bears out this opinion. They are in many respects extremely imperfect, were obviously made on a very small quantity of material, and the formulæ (mostly deduced from a single analysis) are so improbable, that there can be but one opinion as to the necessity for submitting the subject to a further investigation.

Anthracene, as is well known from the observations of Dumas and Laurent, is met with only among the latter portions of the distillation of coal-tar. It has been little seen by chemists, because hitherto the distillation has not generally been pushed so far as to yield it in quantity; but during the last few years, the demand for the asphalt and the higher oils having increased, the distillation has been carried further, and it has been found abundantly in some of the products, and even been used in the manufacture of machinery grease. I have availed myself of the opportunity which a large supply afforded, of extending the examination of anthracene, and with the result of showing that its constitution differs from that attributed to it by its discoverers, and that it is not polymeric with naphthalin.

Before entering on the details of my own experiments, it may be advisable to recapitulate shortly the history of the substance. As already stated, it was discovered by Dumas and Laurent, working in concert, in 1832, and described by the former chemist, who attributed to it the formula $C_{30}H_{12}$, with which his results corresponded very closely. In 1835, Laurent† described, under the name of *paranaphthalese*, a compound to which he gives the formula $C_{30}H_8O_4$, and he appears to have regarded it as a direct product of the action of nitric acid on anthracene. In a subsequent paper‡ he extends his investigation in this direction, and describes no fewer than five different nitro-compounds, and assigns to them very problematical formulæ. In this paper, he again refers to paranaphthalese, but under the name of *anthracenuse*, giving it the formula $C_{30}H_7O_5$, and stating that it is not a pro-

* Ann. Ch. Phys., 1, 187.

† Ann. Ch. Phys., lx. 220. ‡ *Ibid.*, lxxii. 415.

duct of the direct action of nitric acid on anthracene, but formed by the decomposition of a nitro-compound, in a manner precisely similar to that in which naphthase is obtained from nitronaphthalin. He mentions that a substance of similar properties is obtained from several of the nitro-compounds he prepared, but leaves it an open question whether it is in all cases the same, or whether it differs in constitution according to the nitro-compound from which it is produced. He also describes a chlorine substitution-product, and adopts the name of *anthracene*—a change even then advisable, and which the results of my investigation show to be quite indispensable.

Crude anthracene is in the form of a soft yellow mass, not unlike palm oil, but with a greenish tinge and harder consistence; in this state, it contains a little naphthalin and a considerable quantity of oil of high boiling point, which causes it to leave a greasy stain on paper, and to melt easily when rubbed between the fingers. It has a decided though not strong smell, due partly to the naphthalin, but still more to the oil with which it is contaminated, and which it loses on purification. It is soluble, though not abundantly, in alcohol, but dissolves with tolerable facility in ether, turpentine, and still better in benzole. Methylated spirit was in the first instance used for its purification. The first solution, on cooling, deposited thick oily globules, with a small quantity of crystals; but after several successive quantities of spirit had been used, crystals were deposited free from oil, but still retaining the yellow colour of the original substance, and—apparently, owing to the removal of the oil—were much less soluble in new quantities of spirit. By repeated crystallisations, it was found possible to obtain the anthracene quite colourless; but the process was too tedious to be employed for preparing it on the larger scale. Other solvents, and more particularly benzole, were likewise tried; but, though preferable, the complete removal of the colouring matter is difficult with them also, and it was found necessary to begin by distilling the crude substance in a small iron still. The first portions which passed over during the process contained much naphthalin and oil, but were quite free from colour. As the distillation proceeded, however, the colour gradually increased, and at the end a small quantity of a dark green substance remained in the retort. The first portions of the distillate were pressed to remove the oil, and the last portions redistilled so as to get rid of the colour as completely as possible,

and the purification finished by repeated crystallisation from benzole, and sometimes by sublimation.

Anthracene is deposited from its solution in perfectly colourless scales, generally of very small size, even when large solutions have been allowed to cool. Those obtained from spirit are generally the best, and when suspended in the solution, have a fine satiny lustre, which they lose to some extent when dried. From benzole the crystals are somewhat granular, and less brilliant in appearance. By sublimation, it is obtained in thin plates resembling those of naphthalin, but smaller and of inferior lustre. When quite pure, it has no smell, but it is apt to retain a trace of oil, which communicates to it a faint empyreumatic odour. It is entirely devoid of taste. It is not volatile at ordinary temperatures, but is slowly volatilised in the water-bath. At higher temperatures, it sublimes freely. It melts at 416° F. into a transparent colourless liquid, which, on cooling, solidifies into a foliated crystalline mass, and at a higher temperature distils unchanged. It is insoluble in water, sparingly soluble in alcohol, but more so in ether, benzole, and the volatile oils. The alkalies are without action upon it, but sulphuric acid dissolves it, and acquires a green colour, with formation of a sulpho-acid; and nitric acid, even when moderately dilute, acts rapidly upon it. Chlorine and bromine form substitution-products.

The analysis of anthracene at first presented some difficulties. When oxide of copper was employed in the usual way, the carbon was always deficient, while chromate of lead gave an accurate result with that element, but a marked excess on the hydrogen.* Oxide of copper and chlorate of potash were therefore resorted to, and with success.

The results correspond exactly with the formula $C_{28}H_{10}$. This is precisely the constitution of a substance described some years since by Fritzsche† as a new carbo-hydrogen, obtained from coal-tar, with which also its properties closely agree. A careful comparison of the two substances made by Professor Fritzsche and myself, during

* I have had frequent occasion to observe, that in the analysis of carbo-hydrogens with chromate of lead a considerable excess of hydrogen is often obtained. I at first attributed this to impurities in the chromate, but analyses made with a pure material, specially made for the purpose, showed the same excess. I have not examined into the cause of this phenomenon.

† J. pr. Chem. lxxiii. 282.

a visit he paid to Glasgow some time since, satisfied us that his substance really is anthracene. The picric acid compounds of the two are completely identical, and have a fine ruby-red colour, which distinguishes the compounds in question from those obtained from the other carbo-hydrogens. An analysis of the compound obtained from anthracene, gave the formula $C_{28}H_{10}$. $C_{12}H_3(NO_4)_3O_2$, which is that given by Fritzsche for his compound.

Action of Nitric Acid on Anthracene.

Anthracene is but little acted on by cold nitric acid, but the boiling acid, even when moderately dilute, attacks it with considerable rapidity, the products depending upon the strength of the acid and the length of time during which the action is continued.

Oxanthracene $C_{20}H_8O_4$.—When anthracene is boiled for some days with nitric acid of sp. gr. 1·2, red fumes are evolved, and a resinous mass is obtained, which becomes hard and gritty on cooling. The same change may be more rapidly effected with acid of sp. gr. 1·4, but the product is then liable to be contaminated with some other compounds. The substance was washed with water, and purified by crystallisation from alcohol or benzole. It is then obtained in crystals, which, when deposited from alcohol, are long silky needles, but from benzole are shorter and more compact. They are of a light buff colour, and have neither taste nor smell; they are insoluble in water, sparingly soluble in alcohol, and more so in benzole. They are completely soluble in boiling nitric acid of sp. gr. 1·4, and are deposited unchanged on cooling. Concentrated sulphuric acid in the cold dissolves them with orange colour, which becomes deep red on heating, and on dilution with water the oxanthracene is deposited unchanged. Oxanthracene sublimes when heated, and is deposited unaltered in fine needles of considerable length. It may be distilled without decomposition over quick-lime. Its volatility may be taken advantage of as a means of preparing it, as it is only necessary to boil anthracene in a retort with nitric acid, and to continue the heat until the acid has distilled over and the oxanthracene sublimes, any other compounds formed at the same time being decomposed.

Oxanthracene is derived from anthracene by the removal of two equivalents of hydrogen, and the addition of four of oxygen. It belongs to a class of substances of which there are very few

examples, and for which we have no satisfactory system of nomenclature. I have given it the provisional name of oxanthracene, as recalling its mode of formation.

Binitroxanthracene.—When anthracene was boiled for a long time with nitric acid, with occasional addition of fuming acid, red fumes continued to be given off, and a resinous substance was gradually produced. The substance was washed with water and dried. It appeared to be a mixture of some of the last substance with a new compound, which was obtained by heating it with a small quantity of alcohol, and cooling. It is deposited as a red powder which shows but little disposition to crystallise. Analysis gave results affording a distant approximation to the formula $C_{28}H_6\ (NO_4)_2O_4$, which probably represents its constitution; but as its properties showed nothing of interest, I did not prosecute its purification further.

Anthracenic Acid.—When the nitric acid and the washings of the preceding compound are carefully evaporated over the water-bath, a yellow crystalline acid is obtained. It is very soluble in water, and gives crystallisable salts with ammonia and potash, and precipitates the salts of lead and baryta. The further investigation of this substance is reserved for a future communication.

Action of Bromine on Anthracene.

Bromine acts rather slowly upon anthracene in the cold. The two substances when mixed together, concrete into a resinous-looking mass, the interior of which is not completely saturated with bromine, and it was found most convenient to expose the anthracene in a thin layer under a bell glass, along with a capsule containing bromine. After a day or two's exposure, the anthracene agglutinates into a mass which must be removed, reduced to powder, and reintroduced; and this treatment is repeated as long as bromine is absorbed. This mass, which has a brown colour, dissolves in benzole, and on cooling deposits *hexbromide of anthracene* in crystals, which are purified by solution in benzole or ether. It is thus obtained in small hard white granular crystals, apparently rhomboidal. They are sparingly soluble in alcohol, ether, and benzole. Nitric acid acts upon them but slightly. When heated with strong sulphuric acid, they fuse, and bromine and hydrobromic acid are expelled. On digestion with alcoholic potash, they immediately become yellow, and are converted into another compound.

When heated to 348° F. they become brown, and at 361° fuse and give off bromine. Analysis gave the results agreeing nearly with the formula $C_{28}H_{10}Br_6$. The substance is produced by the direct absorption of six equivalents of bromine.

Tetrabrominated Anthracene.—When the preceding compound is treated with an alcoholic solution of potash, it swells up considerably and acquires a bright sulphur-yellow colour, the solution containing bromide of potassium. This change occurs in the cold, but it is more convenient to heat the solution. The yellow powder is collected on a filter, washed, dried, and crystallized from boiling benzole. It is thus obtained in long yellow needles, having a fine silky lustre. It is very sparingly soluble in cold alcohol, ether, and benzole—more so when hot. Boiling benzole is its best solvent, but even of this it requires above a hundred times its weight. It melts at 460° F., and gives a dark-coloured mass, which has undergone partial decomposition. The portions used for analysis were crystallised from benzole, and then washed with ether.

Analysis gives for the constitution of the compound $C_{28}H_8Br_4$, a somewhat unusual formula, differing from that of most similar compounds. In general, when a bromide or chloride of an organic compound is treated with potash, one half of the haloïd is removed in combination with hydrogen, the remainder passing into the radical. In this case, however, only two equivalents of hydrogen are removed, and the formula of the compound ought in all probability to be written $C_{28}H_8Br_2 . Br_2$.

Action of Chlorine on Anthracene.

The examination of the compounds produced by the action of chlorine on anthracene is attended with some difficulty, the changes occurring being of a somewhat complicated kind; more than one substance being generally obtained, and the nature and proportion of the products depending very greatly on the circumstances of the experiment. Chlorine is readily absorbed by anthracene in the cold, and if the current is rapid, it becomes warm, gives off hydrochloric acid in abundance, and is eventually converted into a hard cake. If the chlorine be passed through it in a slow current, the evolution of hydrochloric acid is greatly diminished, although it cannot be altogether avoided; and when this is done, and the stream of chlorine is not continued too long, the principal product is:

Bichloride of Anthracene $C_{28}H_{10}Cl_2$.—The mass obtained by the action of chlorine dissolves readily in benzole, and on cooling, groups of radiating needles, often of considerable length, are deposited. The bichloride is readily soluble in alcohol, but only very sparingly in ether. When crystallised from alcohol, it is very liable to lose hydrochloric acid, and this change always takes place to some extent, which causes a slight excess of carbon and deficiency of chlorine in the analysis.

Chloranthracene $C_{28}H_9Cl$.—When anthracene is treated with a rapid current of chlorine continued for a short time only, this compound is produced. It may also be obtained by decomposing the preceding substance with alcoholic potash. It is soluble in alcohol, ether, and benzole, from the last of which solutions it is deposited in small hard scaly crystals.

When chlorine is passed over anthracene kept hot, it is absorbed in much larger quantity, and hydrochloric acid is abundantly evolved. The compounds thus obtained depend entirely on the length of time during which the current is continued, and products analysed at different periods were found to contain very different quantities of carbon and chlorine; and as the substances produced differ little in solubility, it was found difficult to effect their separation. When the passage of chlorine is continued for about eight days, the product is semisolid, and the greater part dissolves easily in cold ether; and when this solution is evaporated, first an oily chloride and then crystals are deposited. The crystals are soluble in benzole, alcohol, and ether, and were found to have a composition agreeing with the somewhat improbable formula $C_{28}H_9Cl_5$; but it is quite possible that the substance may be a mixture. The oily chloride gives more than one crystalline substance when treated with alcoholic potash.

The facts now detailed are sufficient to fix the constitution of anthracene, and to show that its chemical relations are of considerable interest. Its formula connects it with certain substances derived from oil of bitter almonds, and more especially with stilbene, the carbo-hydrogen discovered by Laurent, from which it differs by two equivalents of hydrogen. A similar relation exists between oxanthracene and benzil, as is seen by the following comparison of their formulæ:—

Anthracene, . .	$C_{28}H_{10}$	Stilbene, . . .	$C_{28}H_{12}$
Oxanthracene . .	$C_{28}H_8O_4$	Benzil, ...	$C_{28}H_{10}O_4$

XI.—*On the source of the Arsenic in the Sulphuric Acid of Commerce, and the preparation of that Acid free from Arsenic.*

By Charles L. Bloxam.

In an account of some experiments upon the electrolytic test for arsenic, published in the Society's Journal for January, 1861, it was stated that I had been unable to procure specimens of sulphuric or hydrochloric acid which did not yield any indication of arsenic when examined by that test. Although the purest samples of these acids furnished by the operative chemist contain so minute a proportion of arsenic that it could not mislead an experienced analyst engaged in a judicial inquiry, still it cannot be denied that if these most important re-agents could be declared incapable of yielding the slightest indication of the poison under the most rigorous scrutiny, greater confidence would be felt by the person eliciting, and—which is perhaps more important—by those receiving the chemical evidence in criminal cases. I therefore beg to submit to the Society the following account of experiments made to ascertain firstly, the possibility of preparing sulphuric acid which should yield no arsenical deposit in the electrolytic test, and secondly, the source of the arsenic in the best samples of the commercial acid.

The sample of sulphuric acid selected for the experiments was taken from the ordinary laboratory supply, and contained so small a quantity of arsenic that no evidence could be obtained by Marsh's test when applied in the ordinary way, though by passing the gas through a narrow heated tube for about half an hour, a slight deposit of arsenic was obtained, and the electrolytic test gave a very decided result.

Experiments were first made upon the method generally recommended for the removal of arsenic from sulphuric acid by converting it into the volatile chloride.

1. Two measured ounces of the acid were mixed with a solution of 100 grains of chloride of sodium in six drachms of water; the mixture was boiled in a flask, the evolved hydrochloric acid gas being passed into two drachms of water. As soon as the volume of the latter had increased to eight drachms, the sulphuric acid

remaining in the flask, and the hydrochloric acid which had distilled over were examined for arsenic, which was found in them distinctly, both by the electrolytic and Marsh's test.

2. Three measured ounces of sulphuric acid were distilled with 100 grains of fused chloride of sodium. After the evolution of hydrochloric acid gas had ceased, two drachms of aqueous hydrochloric acid distilled over, containing enough arsenic to give a yellow tinge with hydrosulphuric acid. Two ounces of the sulphuric acid were then distilled over, each being received separately, but they both contained arsenic, as did also the last ounce remaining in the retort.

3. Four ounces of sulphuric acid were boiled in a flask, and the carefully washed hydrochloric acid gas, from one ounce of salt and two ounces of sulphuric acid, was passed into the boiling acid for half an hour, after which arsenic could still be distinctly detected in it.

Not having succeeded in removing the last traces of arsenic by the action of hydrochloric acid, I next endeavoured to effect it by continued electrolysis; but even after a powerful current had acted during five hours upon the acid, enough arsenic remained to convince me that this plan would be inapplicable. A process of fractional distillation was then tried.

4. Twenty measured ounces of the sulphuric acid were distilled, and the following fractions collected:—(1) 1oz., (2) 4oz., (3) 4oz., (4) 4oz., (5) 4oz., (6) ½oz., leaving about 2oz. in the retort. Each of these fractions contained arsenic, and the residue in the retort was found to contain a larger proportion than the original acid.

Half of the fifth fraction was distilled again, but the first half ounce was still found to contain arsenic, though in very minute proportion.

The remainder of the fifth fraction was distilled with bichromate of potash, in the hope of converting any arsenious into arsenic acid, but the first portion of the distillate gave evidence of arsenic.

Three ounces of the fourth fraction were rectified, the first two drachms being rejected, and 2¼oz. distilled over. This still contained a trace of arsenic, though more was found in the ½oz. left in the retort.

Two ounces of the twice-distilled acid were subjected to a third distillation, the first drachm being rejected. Ten drachms were

distilled over,* and of this thrice-distilled acid two drachms gave evidence of the presence of a trace of arsenic, both by electrolysis and by Marsh's test. No satisfactory result was obtained by distilling the sulphuric acid with permanganate of potash to oxidize the arsenious acid.

My endeavours were next directed to the preparation of pure sulphuric acid from sulphurous acid gas, when I anticipated not the least difficulty in obtaining an acid perfectly free from arsenic.

1. In the first experiments, the sulphurous acid was prepared from sulphuric acid and charcoal, well washed, and oxidized by moist air with the aid of heated pumice-stone coated with platinum. This acid, however, contained more arsenic than the ordinary sample, which was traceable to the hydrochloric acid used in preparing the bichloride of platinum for platinizing the pumice. Moreover, the process was found very troublesome, and furnished too little acid in a given time to answer my purpose.

2. The sulphurous acid, prepared from sulphuric acid and copper,† was very well washed, and oxidized by means of air, steam, and nitric oxide (prepared from nitric acid and copper), in a glass globe, the sulphuric acid being afterwards boiled down in a platinum dish. A trace of arsenic was also found in this specimen.

3. The copper employed in the preceding experiment having been found to contain much arsenic, mercury was next employed for evolving sulphurous acid, but still a trace of arsenic was found in the sulphuric acid produced, and accompanying it was a minute quantity of mercury.

4. Believing it possible, from the result of the last experiment, that the high temperature employed in preparing the sulphurous acid expelled arsenic from the acid in the generating flask, and that washing was incapable of removing the last traces of arsenic from the gas, I next evolved the sulphurous acid at a far lower temperature from crystallized sulphite of soda by the action of sulphuric acid, and in this case it was but just possible to demonstrate the presence of a trace of arsenic. Three trials of this

* It may be worth notice that the residual acid in the retort contained a considerable quantity of platinum in several of these distillations, a piece of platinum foil having been used to prevent bumping.

† The formation of free sulphur and of sulphide of copper was well observed in preparing the large volume of sulphurous acid required in these experiments.

method having given the same result, it was thought that the trace of arsenic might be derived from the copper employed in evolving the nitric oxide.

5. In this experiment, the nitric oxide was prepared from nitre by the action of sulphate of iron and dilute sulphuric acid at a very moderate heat, whilst the sulphurous acid was disengaged as before from sulphite of soda and sulphuric acid.* The resulting sulphuric acid was found to yield not the least indication of arsenic when tested by electrolysis.

Having satisfied myself that it was possible to obtain sulphuric acid which furnished no indication in the electrolytic test, I proceeded to look for the source of the arsenic in the purest specimens of the commercial acid.

By the kindness of the manufacturer, I was supplied with a sample of the Sicilian sulphur employed in the manufacture of one of the purest sulphuric acids, in which, however, the electrolytic test, as well as a prolonged application of Marsh's test, indicated the presence of a trace of arsenic.

This Sicilian sulphur was burnt in air, and the sulphurous acid obtained was converted into sulphuric acid in precisely the same manner as in the last of the experiments above described as giving an acid free from arsenic. The sulphuric acid thus prepared from the Sicilian sulphur gave distinct evidence of the presence of arsenic. A repetition of the experiment with a fresh portion of the sulphur gave the same result.

In order to be quite sure that the arsenic had been derived from the sulphur, I burnt 500 grains of the sulphur, when it left about a grain of a black residue consisting chiefly of sulphide of iron. This was dissolved in a very little nitro-hydrochloric acid; the diluted solution was saturated with hydrosulphuric acid and boiled, when a slight dirty yellow precipitate fell; this was treated with ammonia, which dissolved the yellow portion, leaving a few black particles which proved to be sulphide of lead. The ammoniacal solution, when evaporated, left a yellow residue, which was dissolved in nitric acid; on evaporating the acid and testing with nitrate of silver, the characteristic precipitate of arseniate of silver was obtained.

* I found it advisable, for obvious reasons, to dispense with the use of caoutchouc connectors in the tubes immediately leading to the globe in which the gases were mixed, and to employ a perforated glass plate instead of a cork, for closing the mouth of the globe.

It is evident, therefore, that the sulphur under examination contained a minute proportion of arsenic, part of which passed off with the sulphurous acid when the sulphur was burnt, whilst the remainder was found in the residue with the sulphides of iron and lead.

Though it cannot be inferred, from the examination of a single sample, of the identity of which I have no direct evidence, that Sicilian sulphur always contains arsenic, such an inference is greatly favoured by the circumstance that this impurity has been detected in the specimens of sulphuric acid manufactured with every precaution to insure its absence.

The conclusions to which I have been led by the above experiments are:—

1. That sulphuric acid cannot be completely purified from arsenic either by hydrochloric acid or chloride of sodium, or by repeated distillation, whether alone or with bichromate or permanganate of potash.

2. That the minute quantity of arsenic found, even in the purest samples of commercial sulphuric acid, is derived from the native sulphur employed in its manufacture.

3. That when sulphuric acid is required which shall yield no indication of arsenic to the electrolytic test, the sulphurous acid and nitric oxide employed in its preparation must be evolved at as low a temperature as possible, since the fumes which accompany the gases prepared by the ordinary methods, and are not completely removed by washing, bring over small quantities of arsenic.

It is very probable that experiments conducted upon a manufacturing scale would lead to an easier process for obtaining the sulphuric acid in a state of absolute purity.

Note.—In a former communication, I have stated that arsenic acid does not respond to the electrolytic test. This is not strictly correct, the result depending upon the presence or absence of hydrochloric acid,* although, even when that acid is not present, arsenic acid, as might be expected, does not yield arseniuretted hydrogen so rapidly as arsenious acid. Three experiments were

* Since, in the practical application of the electrolytic test to the detection of arsenic in organic mixtures, hydrochloric acid is always present, the addition of sulphurous or hydrosulphuric acid, as formerly recommended, is still necessary. It was while endeavouring to discover, by electrolysis, the state of oxidation of the arsenic in sulphuric acid, that the reduction of arsenic acid in the absence of hydrochloric acid was noticed.

made with pure arseniate of magnesia and ammonia dissolved in dilute sulphuric acid. A quantity of this solution corresponding to 0·1 grain of arsenious acid gave an immediate deposit of metallic arsenic in the heated reduction tube; one-tenth of that quantity gave a deposit in seven minutes (though not so much as would have been furnished by arsenious acid), and a quantity representing 0·001 grain of arsenious acid gave a deposit in twenty-one minutes.

XII.—*Note on the Composition of a Boiling Spring in New Zealand.*

By Professor Smith, University of Sydney.

Stretching in a north-easterly direction from Taranaki, in the north island of New Zealand, is a line of volcanic action, terminating in White Island, in the Bay of Plenty. In this line are numerous solfataras, boiling springs, basins of seething mud, and hot lakes, presenting, in some localities, scenes of remarkable beauty and grandeur. Some of the boiling springs are intermittent jets, of the same character, though not of the same magnitude, as the geysirs of Iceland. The New Zealand springs have, in many cases, formed terraces and incrustations of siliceous matter, probably unsurpassed, in extent and magnificence, by any similar deposits in the world. One of the most copious of the boiling pools is named "Te Tarata." It is on the shore of Rotomahana ("Hot Lake"), at an elevation of some fifty feet. The water is of a beautiful pale blue colour. It descends to the lake in a series of cascades over the edges of extensive basins and terraces of siliceous deposit. On the occasion of my visit, the water was in violent ebullition, the temperature being a little above that of pure water boiled at the same place. I carried a bottle of it with me to Sydney, and made an analysis of it about a month after its collection. The specimen was then milky, and had a slight smell of sulphuretted hydrogen. Taste soft and unpleasant. It was highly alkaline to test paper. Specific gravity 1·00205. A slight sediment had fallen, which seemed to be chiefly vegetable matter. The quantity of water in my possession was too small for a complete and unexceptionable analysis, but the following Table gives, I believe, a tolerably close approximation:—

	Grains per Gallon.
Silica..	42·40
Soda (probably combined with silica) ..	16·00
Chloride of sodium	113·57
Chloride of potassium	6·67
Sulphate of potash	5·28
Carbonate of lime	1·76
Alumina	0·32
Magnesia and iron	traces
	186·00
Total solid matter obtained by evaporation at 212° F.	189·12
Matter volatilized by ignition	4·00
Leaving for fixed salts	185·12

The arrangement of acids and bases is of course, to a considerable extent, matter of opinion. There being only a small amount of carbonic acid present (not directly estimated), I assume that it is just sufficient to supply the lime. The sulphuric acid found (2·42 grs.) is given to potash, the remainder of the potassium being supplied with chlorine. The potassium (calculated from the precipitate by bichloride of platinum) amounted in all to 5·87 grns. The whole chlorine was 72 grns. There is a residue of soda which, I suppose, may be combined with silicic acid. There could have been no sulphide of sodium present, for the precipitate with nitrate of silver was white, and there was no escape of sulphuretted hydrogen on adding hydrochloric acid to the dry residue obtained by evaporation. Boracic acid was tested for, but none found.

In a bottle of water that I afterwards obtained from the same locality, though, perhaps, not from the same spring, I found solid matter at the rate of 178·8 grns. per gallon. Of this the silica amounted to 57·08 grns., 30·08 grns. being in a state of solution, and 27 grns. having separated as a yellowish-white gelatinous sediment. The chlorine amounted to 70 grns. per gallon.

I examined the white incrustation upon reeds and other objects immersed in the spring. It was silica, with traces of common salt, lime, and alumina. Dried at 212° F., it lost 2·26 per cent. of its weight. On ignition, there was a further loss of 5·05 per

cent., making altogether a loss of 7·20 per cent., calculated on the air-dried powder.

XIII.—*On the Solubility of Sulphate of Lead in Hydrochloric and Nitric Acids.*

By George F. Rodwell.

Perfectly pure and dry sulphate of lead was digested, at ordinary spring and autumn temperature, with the different strengths of hydrochloric and nitric acids given below, in well-stoppered bottles, the mixture being frequently shaken. The time of digestion varied from one to ten days. Determinations of the amount of sulphate of lead dissolved were made on each intermediate day, but it was found that the maximum amount was, in every instance, dissolved before the fifth day of digestion.

The sulphate of lead was allowed a night to settle down; the required quantity of the solution was then filtered off, weighed, and transferred to a porcelain crucible; a few drops of dilute sulphuric acid were added; the solution was evaporated to dryness over a water-bath, and heated in an air-bath to expel sulphuric acid, with the lid on the crucible; and the residue was ignited, allowed to stand in dry air just long enough to cool (previously determined), and immediately weighed.

It was found impossible to evaporate the more concentrated solutions of sulphate of lead in hydrochloric acid over the water-bath: for, when the evaporation was about a third effected, a scum of chloride of lead formed on the surface, and the bubbles of hydrochloric acid, rising from the bottom, burst at the surface of the liquid, throwing particles of the scum outside the crucible, although it was not half full. The evaporation of such solutions was therefore completely effected in an air-bath, the lid being placed on the crucible to prevent the possibility of a particle escaping.

Twenty determinations of the amount of sulphate of lead dissolved by each different strength of hydrochloric and nitric acid were made: the best four and their mean are given.

The following results were obtained:—

100 parts of dilute hydrochloric acid, of the specific gravities given below, dissolve severally of sulphate of lead,—

1. Specific gravity 1·0519 = 10·602 per cent. HCl.
·1468, ·1466, ·1467, ·1465
Mean = ·14665.

On diluting the solution with water, no change was apparent.

2. Specific gravity 1·0800 = 16·310 per cent HCl.
·3546, ·3537, ·3558, ·3557,
Mean = ·35495.

On diluting the solution with water, a few minute needles of chloride of lead came down on standing.

3. Specific gravity 1·107 = 22·0100 per cent. HCl.
·9483, ·9444, ·9476, ·9458,
Mean = ·946525.

On diluting the solution with water, needles of chloride of lead came down.

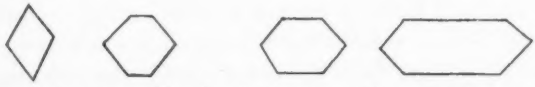
4. Specific gravity 1·1359 = 27·5245 per cent. HCl.
2·1169, 2·1141, 2·1121, 2·1122,
Mean = 2·113825.

On diluting the solution with water, needles of chloride of lead at once came down.

5. Specific gravity 1·1570 = 31·6015 per cent. HCl.
2·8549, 2·8508, 2·8553, 2·8588,
Mean = 2·85495.

On diluting the solution with water, an immediate and abundant precipitate of needles of chloride of lead was thrown down.

If a solution of sulphate of lead in hydrochloric acid be evaporated, we get, on cooling, a number of crystalline plates of pearly lustre. They consist of chloride of lead, and are of the following forms:—



If these plates are dissolved in a small quantity of hot water, *needles* of chloride of lead are deposited on cooling.

When a concentrated solution of sulphate of lead in hydrochloric acid is slowly evaporated, at the rate of about a gramme in two hours, we find that rhombic plates of chloride of lead are first formed. As the evaporation proceeds, however, the small quantity of sulphuric acid present, becoming more concentrated, slowly decomposes these crystals, and we get sulphate of lead in rhombic plates

100 parts of dilute nitric acid, of the specific gravities given below, dissolve severally of sulphate of lead,—

1. Specific gravity 1·079 = 11·55 per cent. NO_5.

·3303, ·3295, ·3300, ·3299,

Mean = ·329925.

2. Specific gravity 1·123 = 17·5 per cent. NO_5.

·5748, ·5763, ·5754, ·5756,

Mean = ·575525.

3. Specific gravity 1·25 = 34 per cent. NO_5.

·7832, ·7835, ·7854, ·7855,

Mean = ·7844.

If any of these solutions are evaporated, we obtain, on cooling, octohedra of nitrate of lead.

4. Specific gravity 1.42 = 60 per cent. NO_5.

·0098, ·0097, ·0097, ·0097,

Mean = ·009725.

If this solution be evaporated to about $\frac{1}{12}$th of its bulk, a small quantity of powder is deposited, which is seen, under the microscope, to consist of octohedra of nitrate of lead.

When sulphate of lead is digested with nitric acid containing 60 per cent. NO_5, it is found, after three or four days, to be almost entirely converted into octohedra of nitrate of lead. On continuing the digestion for twenty-one days, a minute quantity of sulphate still remained unconverted.

From the above results, we see that 1 part of sulphate of lead is soluble, at the ordinary temperature, in—

Dilute Hydrochloric Acid.	Spec. Grav.		Per Cent. HCl.
681·8956 parts	1·0519	=	10·602
281·7298 ,,	1·0800	=	16·310
105·6496 ,,	1·1070	=	22·010
47·3076 ,,	1·1359	=	27·5245
35·0268 ,,	1·1570	=	31·6015

Dilute Nitric Acid.	Spec. Grav.		Per Cent. NO_5.
303·0991 parts	1·079	=	11·55
173·7542 ,,	1·123	=	17·50
127·4859 ,,	1·250	=	34·00
10282·7763 ,,	1·420	=	60·00

XIV.—*On the Resin of* Ficus rubiginosa, *and a new Homologue of Benzylic Alcohol.*

By Warren De la Rue, Ph.D., F.R.S., Treasurer of the Chemical Society, Secretary of the Royal Astronomical Society, &c., and Hugo Müller, Ph.D., F.C.S.

(Abstracted from the Philosophical Transactions, 1860, Part I.)

Among the interesting collection of natural products contributed to the Paris Universal Exhibition of 1855 by the British Colonies, was a gum presenting some remarkable qualities. This substance was stated by the exhibitor to be a new species of gutta percha, in consequence of its becoming plastic when masticated, and on this account it attracted considerable attention. It had been contributed by Dr. Stephenson, of Manning River, N.S.W., who had obtained it from a species of *Ficus*, known as *F. rubiginosa*. The zealous Commissioner for New South Wales, Mr. (now Sir William) Macarthur, brought this gum under our notice, with the view of obtaining some information respecting its chemical properties.

A few preliminary experiments, which were made in Paris, at once showed us that this substance had very little in common with gutta percha, and, moreover, its chemical properties were found to be entirely different from those of that gum. Although our experiments did not allow us to hold out hopes to Mr. Macarthur of the gum becoming a valuable article for exportation from the colony, they offered some inducement to us to make a more rigorous investigation of it on purely scientific grounds. On communicating this view to Mr. Macarthur, he liberally placed at our disposal the remainder of the specimen exhibited.

In pursuing subsequently the study of this subject, we discovered one of the proximate constituents to be a natural acetic ether of a new radical homologous to benzyl (C_7 H_7). The peculiar interest which attaches to this class of compounds, induces us to bring under the notice of the Society the results of our investigation.

This gum or resin exhibits, on the first glance, great similarity in its general appearance to "Gum Euphorbium," occurring, like that substance, in irregular pieces, generally pierced with holes; some specimens also exhibiting a stalactitic formation. The holes in the fragments of this resin are produced by a small beetle of the tribe "Curculio," which apparently feeds upon, and lives in

this resin, as it oozes in a semifluid state from the branch of the tree. We had no means of ascertaining whether or not this insect causes the secretion of the resin by puncturing the branches of the tree, in the same manner as the *Coccus ficus* does for the purpose of depositing its ova. The colour of the gum varies from a dirty yellow or red, almost to white. It is solid and brittle, but some of the larger pieces exhibit, especially in the interior, a degree of toughness which renders it difficult to powder. It is opaque, the fracture being dull and wax-like.

At a temperature of about 30° C. (86° Fahr.) this resin becomes soft, when it resembles gutta percha, being plastic without becoming sticky, provided it has been previously wetted with water. In its natural condition, it has neither taste nor odour; but when heated, it evolves a wax-like odour, and on being masticated evinces a characteristic taste.

In hot or cold water it is perfectly insoluble; but warm alcohol, ether, oil of turpentine, and other solvents of resinous substances dissolve it with facility. Solutions of caustic alkalies have no effect on it, even when aided by heat.

When left for some time in contact with cold alcohol of ordinary strength, the greater part of the resin is dissolved, whilst a white flocculent substance remains undissolved. By employing this solvent, we succeeded in separating several distinct classes of substances from the Ficus resin. The constituent, readily soluble in cold alcohol, formed an amorphous resinous substance, when separated from the solvent by distillation or precipitation with water. The white insoluble part, when further treated with boiling alcohol, is in part dissolved, particles of bark, sand, and other accidental impurities remaining undissolved. The alcoholic solution of the white substance deposits, on cooling, a white crystalline mass, which by repeated crystallization may be obtained in beautiful scaly crystals. From the residue insoluble in boiling alcohol, bisulphide of carbon or chloroform extracts a small quantity of caoutchouc.

A quantitative experiment by the above method yielded the following approximate per-centage result:—

Resinous substance, readily soluble in cold alcohol .	73
White crystalline substances, insoluble in cold alcohol, but soluble in warm alcohol . . .	14
Caoutchouc, fragments of bark, sand, and loss .	13

The resinous substance, readily soluble in cold alcohol, which forms, according to this analysis, by far the principal constituent of our resin, offered but little inducement for chemical investigation. However, a number of experiments were made, which, although unproductive in their results, may serve to characterize this substance, which possesses peculiarities distinguishing it from other bodies of like origin. In order to identify it hereafter, we propose to call this resin Sycoretin. At the same time, we must state that we were not successful, for reasons hereinafter mentioned, in obtaining this substance perfectly pure.

Sycoretin.

Cold alcohol of moderate strength dissolves the principal part of the original resin, forming a light brown solution, which on precipitation with water, or the separation of the alcohol by distillation, yields the sycoretin. The alcoholic solution of this resin is perfectly neutral, and scarcely any precipitate is caused in it on the addition of an alcoholic solution of acetate of lead or acetate of copper. This behaviour indicated at once that no acid compounds were present, and that the resin is perfectly neutral. The minute precipitate which formed we ascertained to be tannate of lead, the source of the tannic acid being probably the bark which contaminated the resin. This resin was purified by redissolving it in alcohol, and in order to remove the small amount of colour, the solution was treated with animal charcoal, but this had no effect. No better result was obtained when a small quantity of acetate of lead was introduced into the solution, and a basic lead-salt thrown down with ammonia. We afterwards found that the colour could be gradually removed by repeated precipitation of the resin from its alcoholic solution by water.

The decolorized resin was now redissolved in a just-sufficient quantity of alcohol, and the solution left for some time in a cool place, when a small amount of crystalline substance was deposited, which was filtered off. By addition of a little water, a small quantity of sycoretin was then thrown down, in order to carry down the last traces of the less soluble crystalline compound, in case any were still present. After this treatment, the solution was again allowed to stand for some time, but no further precipitate was formed. The clear solution was now partly precipitated with water, and the precipitate removed after it had subsided, heat being used to facilitate the subsidence of the sycoretin by causing the

precipitate to agglutinate into one mass. That part of the resin remaining in solution was afterwards thrown down with water and collected separately.

The two different lots of resin thus obtained had the same appearance; both were brittle, but only the last became sticky when masticated, and tasted like the original resin. Both products were powdered and kept for some time *in vacuo* over sulphuric acid, in order to remove all traces of any adhering water or alcohol.

The analysis of the first precipitated part (A) gave the following per centages :—

Carbon . .	74·65	Hydrogen . .	10·11

The analysis of the portion last thrown down (B) gave the following per-centages :—

Carbon . .	77·89	Hydrogen . .	9·94

It will be observed from the preceding numbers, that the resin, which has the property of agglutinating on being masticated, is richer in carbon than that first thrown down by water from the alcoholic solution. The peculiar characters of these substances did not, however, permit of any formulæ being determined for them.

Sycoretin is almost white; it is very brittle. It melts in boiling water to a thick liquid, floating on the surface, and when powdered becomes so electric that it flies out of the mortar. In water, dilute acids, alkaline solutions, or ammonia, it is insoluble; but it is readily soluble in alcohol, ether, chloroform, oil of turpentine, &c.

In order to ascertain whether sycoretin was allied to that class of bodies called glucosides (jalapin, for example), the following experiments were made :—

Action of Sulphuric Acid on Sycoretin.

A portion of the sycoretin, prepared, as stated above, by fractional precipitation, was added to concentrated sulphuric acid; it was readily dissolved, forming a fine deep red solution, which gave off only a faint odour of sulphurous acid when kept for several days. By exposure to the air, or on addition of water, a brownish precipitate deposited, which differed from the original solution by its lesser solubility; the aqueous liquid contained a trace of a

sulpho-copulate acid, but no saccharine substance could be discovered. Analogous results were obtained by treating it with a concentrated solution of potash. These experiments show that sycoretin cannot be classed with the glucosides; moreover, all attempts to place this substance in connexion with some of the classified organic compounds were unsuccessful, and we are therefore constrained to leave it for the present among the so called resins, under which term are comprised all sorts of bodies, acid and neutral, which have nothing in common except some physical resemblance.

Action of Nitric Acid on Sycoretin.

It appears that the only products of the action of concentrated nitric acid, are a peculiar nitro-compound and a small quantity of oxalic acid, no picric acid being formed.

On submitting sycoretin to the action of nitric acid, the powdered resin was introduced in small quantities into the acid at the ordinary temperature, and when the action had somewhat subsided, the acid was boiled for some time, when every particle of resin disappeared. The resulting yellow liquid was mixed with water, when a copious precipitate of a pale yellow colour was formed. The precipitate was filtered off, and washed with water. The filtrate, when freed from nitric acid by evaporation, gave an additional precipitate of the nitro-compound on admixture with water. The nitro-compound has slightly acid properties, and is readily soluble in solutions of potash and ammonia. Carbonate of potash also dissolves it, but there is no evolution of carbonic acid, even when the solution is warmed. All the solutions in alkalies are dark yellowish brown, and leave on evaporation an amorphous residue. Lead and other metallic salts give coloured precipitates with its solution, but, as might be expected, no definite compounds could be produced in this way. The compound with potash, when heated on platinum-foil, melts, takes fire, puffs up, and burns with the vivacity of other nitro-compounds.

Action of Heat on Sycoretin.

When heated in a retort, sycoretin melts below 100° C. and, at a temperature of a few degrees higher, froths considerably, giving off water which retains the peculiar odour perceptible on heating the original resin. On raising the temperature much higher, it becomes quiet, and begins to decompose, giving off at

first a mobile liquid, and towards the end a dark yellow tar-like substance, leaving only a small quantity of charcoal behind. The distillate so obtained has a disagreeable smell, somewhat like burnt india-rubber, acetic acid being also present in considerable quantity.

By treating it with a solution of carbonate of sodium, the acetic acid is removed, a dark brown oily liquid remaining, which possesses now a less disagreeable odour. This oily liquid, submitted to a new distillation, gives at first a very mobile liquid, possessing in every respect the properties of caoutchin, and then a thick oily liquid, which soon becomes dark brown when exposed to the air.

Acetate of Sycoceryl.

We assign this name, for reasons hereafter to be mentioned, to the crystallizable substance, which, as already mentioned, is obtained when the residue, left after the treatment of the original resin with cold alcohol, is dissolved in boiling alcohol, and the solution allowed to cool.

For the preparation of this substance, the original resin is coarsely powdered and extracted with cold alcohol, in order, as far as possible, to remove the sycoretin. The undissolved residue is then exhausted with boiling alcohol. The several solutions thus obtained are filtered and allowed to cool, when a white deposit is formed, which generally shows but little indication of crystallization. This white deposit is again dissolved in a large quantity of boiling alcohol, and left in a quiet place to cool slowly, when a more perfect crystallization is obtained.

Towards the latter part of the crystallization, a substance is deposited of different appearance, being of a more flocculent nature, and altogether different from the crystals first deposited. This substance is present only in very small quantity, and its separation from the other crystallizable constituents of the resin is attended with great difficulties. In order to effect this separation, the alcoholic solution is allowed to cool to about 40° C. (104° Fahr.), and then the crystals which may have formed are separated by straining off the liquor as quickly as possible through a piece of gauze. The mother-liquor, on further cooling, will now deposit the flocculent substance, contaminated, however, with the first substance. By repeating this operation, a perfect separation of this second substance may be effected.

By repeated solution in and recrystallization from hot alcohol, the crystalline substance (acetate of sycoceryl), was obtained

perfectly white and transparent and apparently pure. An examination with the microscope, however, proved that another foreign body had deposited in smaller crystals on the faces of the supposed pure substance. This new body proved to be much less soluble in different vehicles than our acetate of sycoceryl, but, being present only in very small quantity, its separation caused us at first very great perplexity, but finally we found the following method perfectly efficacious for that purpose.

The dry crystals were placed in a flask, and a quantity of ether insufficient to dissolve the whole substance was introduced, the temperature being maintained at about 30° C. (86° Fahr.); more ether was cautiously added from time to time until the larger crystals had just disappeared, leaving the smaller ones of the new substance undissolved. The separation of the two substances is not, however, perfect in a single operation; for when the flask is allowed to cool, a small part of this parasitical body deposits. After distilling the filtered etheric solution, the acetate of sycoceryl is obtained in a state of perfect purity, and by recrystallization from alcohol, ether, or chloroform, it may be procured in beautiful crystals.

Acetate of sycoceryl so obtained is perfectly colourless, and crystallizes from ether in flat prisms, which generally appear as six-sided plates. When crystallized from alcohol, the crystals are thin and scaly like mica, and have the greatest resemblance to cholesterin.

Acetate of sycoceryl is brittle, yet difficult to powder, on account of its becoming highly electric when triturated. It melts at 118° —120° C. (244°·4—248° Fahr.), and is still fluid when cooled down to 80° C. (176° Fahr.). It solidifies at first to a transparent mass, which, however, after a short time, becomes opaque and crystalline, especially if scratched with a hard body. Heated considerably above its melting-point, it boils and distils, almost without decomposition. The distillate is at first liquid, but solidifies after some time, and becomes gradually crystalline. When not perfectly pure, or if the heat is applied too rapidly, it gives out a rancid odour, in which that of acetic acid is recognizable. Hot alcohol, ether, chloroform, benzol, acetone, oil of turpentine, and concentrated acetic acid dissolve the acetate of sycoceryl with great facility. The alcoholic solution is perfectly neutral, and gives no precipitate with alcoholic solutions of the acetates of lead or copper.

Sulphuric acid dissolves it readily, forming a viscid colourless

solution, which gets gradually brown, and then gives off traces of sulphurous and acetic acids. When the sulphuric solution is mixed with water, a substance is thrown down which is perfectly hard at common temperatures, but melts below 100° C. (212° Fahr.), and is very difficultly soluble in alcohol, but readily so in chloroform and benzol.

Nitric acid, when diluted, has no effect, at ordinary temperatures, on acetate of sycoceryl; but if warm, it evolves nitrous fumes, and produces a yellow resinous compound. Fuming nitrous acid, however, dissolves it readily at ordinary temperatures, giving a yellow solution from which water throws down a flocculent amorphous yellow nitro-compound.

Hydrochloric acid has no effect on acetate of sycoceryl.

Chlorine, bromine, and iodine in contact with this substance act upon it with violence, especially the two first-named reagents; the products, however, procured in this manner are only resin-like compounds not adapted for analysis.

If, however, a warm alcoholic solution of the acetate of sycoceryl is employed, and the bromine or iodine also added in solution, and in small quantities at a time, the colour of these two reagents disappears, and after cooling, a new bromo- or iodo-compound, as the case may be, is deposited in small crystals. The iodine-compound is yellow, the bromine-compound colourless. The purification of these two promising compounds, and their separation from the unaltered original substances, and another resinous body formed at the same time, was unfortunately not possible with the limited quantity of material that could be devoted to their preparation.

Solution of potash, even when boiled for a long time with the substance under consideration, does not act upon it. If hydrate of potash, however, is melted with it, a decomposition takes place, and if the temperature is raised, some hydrogen is given off. The product of this reaction, treated with water, leaves behind a colourless amorphous body, which could not be obtained in a crystalline state, or sufficiently pure for analysis. The alkaline mother-liquor saturated with diluted sulphuric acid became slightly turbid, and the presence of acetic acid was then perceptible. Soda-tartrate of copper gave no reaction indicating the presence of sugar in the solution.

Thus far we did not succeed in producing any derivative which would throw light upon the theoretical composition of our substance, and furnish us with the means of ascertaining its rational formula.

Analysis gave numbers which agree with the empirical formula $C_{10}H_{16}O$,* our substance being accordingly isomeric with camphor, to which, however, it has no further resemblance.

This composition varies also widely from that of the crystalline substances procured from analogous sources, and which have a great resemblance to our substance,—for instance, the crystalline resins on the one hand, Chinese wax and waxes generally on the other.

We have mentioned above, in speaking of the action of various reagents on our new substance, the occurrence of acetic acid under two different circumstances; we did not attach much importance to this fact at the time, because this acid occurs so frequently among the products resulting from the breaking up of organic substances; nevertheless, we subsequently repeated these experiments on a somewhat larger scale, chiefly, however, with the view of studying the other products of decomposition which are formed. In order to eliminate as much as possible the effect of temperature, we made use of that powerful reagent, the so-called "sodium-alcohol," which is obtained by dissolving sodium in absolute alcohol. Sodium-alcohol and potassium-alcohol at ordinary temperatures are, for the most part, equivalent in their reactions to the hydrates of those alkalies when in a state of fusion, and hence present the advantage of effecting decompositions in a more simple manner, the effect of a high temperature not interfering with the final result, as is sometimes the case when the fusing hydrated alkalies are employed.

Some experiments of this kind, performed with great care, convinced us that the occurrence of acetic acid could not be attributed to the effect of empyreumatic decomposition, but that it actually existed as an integral proximate constituent of our crystallizable substance. This led us at once to suspect that our substance was in reality an ether-like compound. This supposition was confirmed by the separation of a body which might be considered as the hydrated oxide of a radical; moreover, we were ultimately enabled to give the fullest confirmation to this theoretical speculation, by actually producing the original substance in a manner suggested by this view.

It should be stated that sodium-alcohol dissolves our substance with the greatest facility, and even at a temperature of 30° C.

* Carbon = 12 Oxygen = 16.

(86° Fahr.) decomposition takes place, the reaction being unaccompanied by the evolution of gas. On cooling, the solution continues liquid, although a large quantity of the substance may have been employed; but on addition of water, a white flocculent substance separates from the colourless alkaline mother-liquor.

The flocculent substance is insoluble in water, but readily soluble even in cold alcohol. When it is dissolved in a quantity of boiling alcohol, just sufficient to take it up, the solution on cooling solidifies completely to a mass of beautiful silky crystals, quite different from those of the original substance: this new derivative proved to be the new alcohol, which we propose to call Sycocerylic Alcohol.

The aqueous liquor from which the flocculent precipitate was separated, remains almost perfectly clear, on saturation with a mineral acid; on examination, no other product besides a volatile organic acid could be found in it. The existence of a volatile acid with the odour of acetic acid, was rendered evident by saturating the alkaline mother-liquor with phosphoric acid and distilling; the distillate was saturated with carbonate of barium and evaporated to the crystallization point, when prismatic crystals, of the characteristic form of acetate of barium, were obtained. A barium determination gave numbers which agree with the formula, $C_2 H_3 BaO_2$.

Alcohol of Sycoceryl.

The preparation of this substance has been already detailed. In order to render it pure, it is only necessary, after it has been precipitated from the solution of sodium-alcohol, to wash it well with water in order to remove all traces of fixed alkali; then to crystallize it a few times from warm alcohol. The crystals usually occur aggregated in spherical masses, like the mineral Wavellite; they are very thin, and have a great resemblance to caffeine.

In several instances, during the earlier stages of its purification, or when dilute alcohol is employed for its solution, it was noticed that the substance did not deposit in crystals, but the transparent liquid congealed to a jelly. This jelly, however, after some time became crystalline, the crystallization commencing in several points of the mass, and extending gradually throughout the whole; ultimately a crystallization was obtained of the same appearance as occurs under other circumstances.

In the determination of the rational formula of this substance,

we took cognizance of the fact, that, besides acetic acid, it was the only other product obtained in the decomposition of the original compound which we have denominated acetate of sycoceryl, and the analysis of which led to the empirical formula $C_{10}\,H_{16}\,O$.

From the nature of this compound, we inferred that it contained the radical of acetic acid in a state similar to that in which it exists in acetic ether; that, in fact, we had to deal with a compound containing acetic acid minus one atom of hydrogen and a radical. According to this view, the empirical formula $C_{10}\,H_{16}\,O$ would have to be doubled, whereby we obtain

$$C_{20}\,H_{32}\,O_2$$

and if we now deduct the elements of acetic acid minus hydrogen $= C_2\ H_3\ O_2$

we have $C_{18}\,H_{29}$

for the radical of our new alcohol, whose formula would consequently be $C_{18}\,H_{30}O$.

The analysis of the supposed alcohol obtained from acetate of sycoceryl gave results which support this view.

According to the formula $C_{13}\,H_{30}\,O$, the new alcohol would be homologous with benzylic alcohol obtained from "oil of bitter almonds."

Alcohol of sycoceryl is perfectly insoluble in water, the fixed alkalies, and ammonia; but alcohol, especially when warm, also ether, benzol, chloroform, and naphtha, are good solvents for it.

At a temperature of about 90° C. (194° Fahr.), sycocerylic alcohol melts to a liquid heavier than water, and solidifies on cooling to a crystalline mass, especially if any fragments of crystals have remained unfused, because they become the foci of a new crystallization. When, however, the heat is increased only a little beyond the fusion point, it remains perfectly transparent and amorphous. By contact with alcohol, this glassy condition is changed to the normal crystalline structure. When it is heated considerably above its melting-point, a portion distils unchanged, and a brownish residue is left in the retort.

Potassium brought in contact with this substance when in a state of fusion, disengages hydrogen, and becomes covered with a white crust; but when heat is applied in order to fuse the so-formed potassium-compound of the sycocerylic alcohol, the reaction becomes so violent that the mass blackens and even catches fire.

Heated with hydrate of potash above the melting-point of the latter, it evolves hydrogen and decomposes; it appears that this reaction does not stop with the probable formation of an acid which unites with the potash, but goes further; for in the product of this reaction we did not find the expected acid; but it is our intention to pursue this subject if ever we are so fortunate as to procure a larger supply of material.

Concentrated sulphuric acid easily dissolves sycocerylic alcohol with evolution of heat, forming a brown liquid which remains unaltered for some time. The liquid yields, on addition of water, a resinous viscid substance, which melts at the temperature of boiling water, and is but very sparingly soluble in alcohol. Ether and chloroform dissolve it with facility, and, on evaporating, merely leave the resinous product in its original amorphous state. The aqueous liquor, saturated with carbonate of barium, gave no indications of the presence of a conjugated sulphuric acid.

Chlorine, bromine, and iodine act readily on sycocerylic alcohol: if solutions of these reagents are used, crystalline compounds are formed. The iodine-compound is of a yellow colour.

Action of Chloride of Phosphorus on Sycocerylic Alcohol.

For the purpose of preparing the chloride of sycoceryl, we employed pentachloride of phosphorus and a solution of sycocerylic alcohol in benzol. At common temperatures, no reaction took place, but when the temperature was raised to about 60° C. (140° Fahr.), hydrochloric acid was given off, and the pentachloride gradually disappeared. After the disengagement of hydrochloric acid had ceased, the liquid was removed from the remaining pentachloride and washed with water, and afterwards with an alkaline solution. After the benzol had been got rid of by keeping the liquid for some time in a warm place, a viscid residue was obtained, which was soluble with great difficulty in alcohol, but easily soluble in ether or chloroform. These solutions, after evaporation, deposited this substance again in its original sticky state. In the first experiments, which were carried out only on a very small scale, a crystalline substance was formed besides the amorphous greenish compound. This crystalline substance differed in its properties from the original alcohol. It therefore seems probable that a slight excess of pentachloride (or the phosphoric acid formed during the reaction) destroys to a great extent the chloride of sycoceryl formed during the reaction; or at all events, phosphate

of sycoceryl, which is produced simultaneously and predominates, cannot be separated from the chloride. We are therefore at present unable to give a description of the chloride of sycoceryl in its pure state.

Benzoate of Sycoceryl.

Chloride of benzoyl dissolves with the greatest facility a large quantity of sycocerylic alcohol at common temperatures, but no hydrochloric acid is disengaged; probably, therefore, no reaction takes place at ordinary temperatures, but if heat is applied, the liquid soon commences to give off hydrochloric acid. When the evolution of hydrochloric acid has ceased, the mixture is allowed to cool, when it solidifies to a fibrous crystalline mass. Any excess of chloride of benzoyl is removed after the reaction by throwing the mixture into a solution of bicarbonate of potassium, whereby a resinous mass separates. The whole being kept warm for several hours, all the chloride of benzoyl is decomposed. During this process, a slight smell, somewhat like benzoate of ethyl, is perceptible. The resinous mass, after removal from the saline liquors, is washed several times with warm water; it is now free from benzoic acid and chloride of benzoyl. On boiling the resinous mass with absolute alcohol, a trace of a yellowish secondary product dissolves, leaving the principal quantity undissolved, which then appears as a white crystalline mass.

When the product thus obtained is boiled with a large quantity of ether, and the solution allowed to cool, small crystals are deposited, which are soluble with difficulty in ether. Absolute alcohol dissolves only a trace of this substance, and when boiled with it deposits the dissolved part, on cooling, in minute spherical aggregations of crystals, which under the microscope are seen to be prismatic.

The best solvent for this compound is benzol, it being soluble in all proportions in this liquid. On evaporating the solution, the substance is left behind in fine prismatic crystals. Chloroform behaves like benzol: but the crystals obtained from this solvent are much finer, and can be obtained of considerable size.

In order to ascertain the nature of the compound produced by the action of chloride of benzoyl on sycocerylic alcohol, we decomposed it by means of sodium-alcohol, which we found to be preferable to any other form of caustic alkali. Even with this reagent the decomposition is effected only with difficulty, possibly on account of the new substance being only sparingly soluble, and

also on account of the resulting benzoate of sodium not being much more soluble in the alcohol. However, after boiling for some time, the benzoate of sycoceryl disappears. On addition of water, a bulky substance was separated, which proved to be the regenerated alcohol of sycoceryl.

The aqueous liquid saturated with an acid soon formed a crystalline precipitate, which, on removal with ether, proved to be benzoic acid.

The foregoing experiments bear conclusive evidence that the alcohol of sycoceryl behaves towards chloride of benzoyl in a manner perfectly analogous to that of other members of the alcoholic group, producing, that is to say, a benzoate of the ether-radicle.

After having shown that the substance separated by sodium-alcohol may be regarded as the alcohol of the new radicle sycoceryl, it became desirable to have a synthetic proof of this theory; and it occurred to us that if we could succeed in combining the sycocerylic alcohol again with the radicle of acetic acid, and thus reproduce the original substance, which we have called acetate of sycoceryl, it would be the best possible confirmation of our views. In order to test this, we accordingly brought chloride of acetyl in contact with sycocerylic alcohol. At ordinary temperatures, no action took place; but when a little heat was applied the alcohol was dissolved, and the liquid commenced to boil, giving off copious fumes of hydrochloric acid. After the reaction had ceased, heat was again applied, and the whole subjected to the boiling temperature for some time, in order to get rid of the excess of chloride of acetyl. After cooling, the resulting product was boiled with water, when a heavy oily body separated. The boiling with water was continued for some time, until at last the oily liquid became perfectly solid and beautifully crystalline, indicating at once that a substance had been formed differing from the original alcohol, which, it will be remembered, is fluid at the temperature of boiling water.

This white crystalline substance was now dissolved in boiling alcohol, of which it required a considerable quantity, and subsequently allowed to cool. When almost the whole had dissolved, a small quantity of a compound was left behind, which at last melted, being evidently a new substance, the probable product of the action of a small quantity of oxychloride or phosphorus which contaminated the chloride of acetyl.

On cooling, the filtered liquid began to crystallize, yielding beautiful iridescent flat prismatic crystals, which sparkled with the colours of the rainbow in the solution, like chlorate of potash in the act of crystallizing. The crystallized substance produced in this experiment proved to be in every respect identical with the natural acetate of sycoceryl, and thus gave the most direct confirmation to our theoretical views.

Having thus established the nature of the sycocerylic alcohol, it became desirable to produce also the acid which would be homologous with benzoic acid, and would bear to this acid a relation similar to that which palmitic acid bears to the lower members of the series to which it belongs. A small quantity of the alcohol was therefore boiled for about six hours with dilute nitric acid. A feeble reaction was indicated by the slight evolution of nitrous fumes, and after some time the sycocerylic alcohol became of a dark yellow colour, and presented a resinous aspect. After digesting for six hours, the resinous product was removed, washed with water, and dried. This substance was readily soluble in warm alcohol, and on cooling a white crystalline substance was deposited.

This crystalline substance had all the characters of an acid; it was perfectly soluble in an aqueous solution of potash or ammonia, and gave with an alcoholic solution of acetate of lead a copious precipitate. Although this reaction showed that we had obtained an acid which possesses all the properties that might be anticipated of an acid corresponding to our alcohol, we could not, with the very small quantity of substance at our disposal, get enough of it in a pure state for analysis, on account of the yellow nitro-compound (apparently the nitro-acid of the new acid) adhering with great obstinacy to it, and accompanying it in all its compounds and solutions. In order to exclude the formation of this secondary product, we tried the action of chromic acid on sycocerylic alcohol; a small quantity of the alcohol was boiled with a moderately concentrated solution of chromic acid for about eight hours. The product so obtained was washed and boiled with a dilute solution of potash, but after saturating this alkaline solution with an acid, no precipitate was formed, and it was altogether impossible to detect any acid: therefore we must conclude that this acid was not formed by this treatment.

On one occasion, on repeating this experiment, we accidentally observed, among the products of the action of chromic acid on sycocerylic alcohol, a crystalline body; on treating the mass with dilute

alcohol, this product was procured in large flat prisms, resembling somewhat in appearance the acetate of sycoceryl, but differing in its melting-point, and was perfectly neutral. From the mode of formation, it might be inferred that we had obtained the aldehyde ($C_{18}H_{28}O$) corresponding to our alcohol, but the minuteness of the quantity procured rendered it impossible to decide this point.

For the present we must content ourselves with the foregoing account of the compounds of the radicle sycoceryl, the very small amount of the substance at our disposal being barely sufficient for the performance of those experiments which we have described.

The great interest which naturally attaches to this new homologue of the benzyl-alcohol series will be a sufficient inducement for us to take up this subject again, for the purpose of studying its derivatives, should we be so fortunate as to obtain a further supply of raw material.

On reviewing the members of which Cannizzaro's benzylic alcohol is the type, and with which our new alcohol must be classed, it will be perceived that there are still many gaps to be filled up in their series.

Benzylic alcohol	C_7H_8O	
	$C_8H_{10}O$	unknown.
	$C_9H_{12}O$	
Cuminylic alcohol (Thymol and Carvacrol).	$C_{10}H_{14}O$	
	$C_{11}H_{16}O$	
	$C_{12}H_{18}O$	
	$C_{13}H_{20}O$	
	$C_{14}H_{22}O$	unknown.
	$C_{15}H_{24}O$	
	$C_{16}H_{26}O$	
	$C_{17}H_{28}O$	
Sycocerylic alcohol	$C_{18}H_{30}O$	

On comparing the properties of our sycocerylic alcohol with those of benzylic alcohol, very little resemblance will at first be traceable between them; but when it is remembered that there are not fewer than ten steps between benzylic and sycocerylic alcohol, this difference of properties is easily accounted for; more particularly if we take into consideration a similar case in another homologous series, the links of which are more fully known. The change in the properties of the acetic acid series, for example, by each increment of increase of CH_2, is quite as remarkable; and when we

compare acetic acid on the one hand, with palmitic acid on the other, the dissimilarity is not less remarkable than if we compare sycocerylic alcohol, $C_{18} H_{30} O$, with benzylic alcohol, $C_7 H_8 O$.

In conclusion, we may mention that benzylic alcohol, and consequently also cuminylic alcohol, are generally considered to be homologues of phenyl-alcohol (carbolic acid); cresyl-alcohol would be isomeric with benzyl-alcohol, and carvacrol and thymol with cuminylic alcohol. On comparing these substances, we find that this view is not tenable, and that there exist in reality at least two distinct series of isomeric compounds, the types of which are benzylic alcohol on the one hand and phenylic alcohol on the other.

The crystalline substance which adhered to the acetate of sycoceryl, and which it will be recollected was left in part undissolved when the acetate was dissolved out with ether, can be obtained in only very small crystals. It is perfectly neutral, and we did not succeed in obtaining any derivative from it calculated to throw light on its true nature. The quantity was indeed extremely small, and we therefore content ourselves with giving the results of the ultimate analysis of this substance, which was found to contain 75·56 per cent. carbon and 12·30 per cent. hydrogen.

XV.—*On a Deposit of Crystallized Xanthin in Human Urine.*

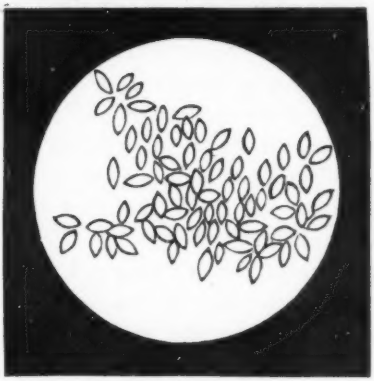
By H. Bence Jones, M.D., F.R.S.

In July, 1861, I was consulted regarding a schoolboy, nine years and a half of age. The following history was given to me. He had good health until seven years old, when he was seized one night with violent sickness and pain in the stomach, which continued incessantly for three days. Neither mustard poultices, blisters, nor leeches relieved the pain or stopped the sickness. The third day his water gradually became of the colour of blood; it then stopped altogether, and nothing was passed for four days; then delirium and convulsions came on, and these lasted for twenty-four hours, when he was relieved by a most violent perspiration. No stone was seen to pass. In a few days he was perfectly well, and continued so for nearly three years, when in

June, 1861, he caught a slight cold, and was delirious one night. A medical man saw him and found some albumen in the urine, which then was generally thick, and the quantity of deposit was increased by excitement, or temper; cold produced the same effect in a less degree. He never complained of pain in the back, and was able to take more exercise than other boys of his age without fatigue. He always had a good appetite, and was allowed to eat everything.

On examination I found a very small quantity of albumen in the water made at night, and none in that made in the morning. There were no blood cells, no tubular casts, and the specific gravity was high. I examined many specimens without finding anything remarkable.

About the end of July, when he was leaving London, a small vial of urine was sent to me, which was quite thick and deep-coloured. A drop was placed under the microscope, and a crystalline deposit was found resembling one form of uric acid. From the form I considered the deposit was uric acid.

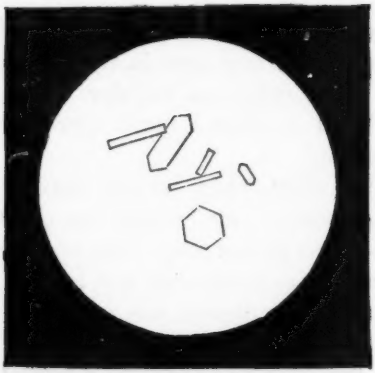


On examining the unfiltered urine for albumen by heat, I was surprised to see the crystalline deposit entirely dissolve. A fresh portion of sediment showed the same crystalline appearance and the same solubility by heat. This was so utterly unlike any uric acid deposit, that a closer examination of the sediment was made, but so little substance was left that no satisfactory conclusion could be arrived at, except that it was not uric acid.

A day or two afterwards another specimen was brought to me containing the same crystalline deposit soluble by heat. The

sediment formed about an eighth of the bulk of the fluid. It was collected on a filter, washed with alcohol, and it gave the following reactions. It dissolved in water and in hydrochloric acid; when treated with nitric acid, it dissolved without effervescence, and when evaporated to dryness, it left a yellow residue.

When the solution in hydrochloric acid was evaporated to dryness it left beautiful minute crystals of this form:—



These crystals were soluble in water.

The sediment was easily dissolved by alkalies.

The watery solution of the sediment had a feebly acid reaction, and when evaporated to dryness, left an amorphous residue, which was again easily dissolved in water.

These reactions agree only with the latest and best observations of the reactions of xanthin.

Hoping to get more of the substance, I wrote to the country for the sediment of the urine. It was collected on many occasions, but I could only find urates and uric acid, and none of the crystalline deposit soluble by heat.

In January, 1862, the same boy was brought to me, with two specimens of urine and four different dried deposits; and at different times for three weeks I examined the urine. It was generally of high specific gravity, 1025, 1026, 1027, 1030; once as low as 1013. It sometimes contained a trace of albumen. Usually it contained urates, and sometimes uric acid and oxalate of lime, but never the crystalline deposit soluble by heat.

The dried deposits consisted of urates and uric acid, and one of them consisted of phosphate of lime, with a little phosphate of ammonia and magnesia, without a trace of uric acid or xanthin.